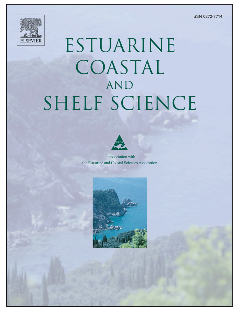
Accepted Manuscript



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PII: S0272-7714(17)31070-3

DOI: 10.1016/j.ecss.2018.03.018

Reference: YECSS 5795

To appear in: *Estuarine, Coastal and Shelf Science*

Received Date: 5 November 2017

Revised Date: 16 March 2018

Accepted Date: 19 March 2018

Please cite this article as: Delpeche-Ellmann, N., Soomere, T., Kudryavtseva, N., The role of nearshore slope on cross-shore surface transport during a coastal upwelling event in Gulf of Finland, Baltic Sea, *Estuarine, Coastal and Shelf Science* (2018), doi: 10.1016/j.ecss.2018.03.018.

The role of nearshore slope on cross-shore surface transport during a coastal upwelling event in Gulf of Finland, Baltic Sea

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ABSTRACT.

The wind induced coastal upwelling process often contains a mid-phase that involves coherent long-living cross-shore surface jets of cooler water. These jets extend to 40–45 km from the coast and tend to start from particular coastal locations. We develop a simple method for evaluating the depth in the water column from where the upwelled water originates. We also test the hypothesis that the development of cross-shore surface jets may be triggered by some permanent characteristics such as the bathymetry or the slope of the nearshore seabed. The analysis is performed for a strong and well-documented upwelling in the Gulf of Finland, the Baltic Sea, using high resolution bathymetry data, satellite derived sea-surface temperature, surface currents measured by in situ drifters, and properties of water masses in two sampling locations. The results indicate that the cross-shore jets originate exclusively from the shore sections with much steeper slopes (>0.0075) than in the rest of the study area. The cooler water most likely origins from intermediate water masses at depths between 15–30 m. The resulting identification of the source depth of the upwelled water and its spatial location assists in understanding the flux of nutrients during upwelling events and their link to the onset of cyanobacteria blooms.

Keywords: upwelling, bathymetry, satellite, cross-shore jets, Gulf of Finland

Highlights

- Bathymetry of the offshore plays a major role in the onset of cross-shore jets
- Cross-shore upwelling jets likely start from steep nearshore segments.
- The source depth of upwelled waters may be estimated from the extent of cross-shore jet.
- This depth discloses the flux of nutrients (phosphates or nitrates) brought up to surface.

1. Introduction

Wind-driven coastal upwellings serve as a core mechanism responsible for the vertical exchange of water masses and different substances in the World Ocean. Recent studies have also indicated that such phenomena (e.g., upwellings in the Southern Ocean) may even influence our climate and ecosystem globally (Anderson et al., 2009; Morrison et al., 2015). Among several interesting aspects of the upwelling phenomena, this study focuses on the role of the near-shore slope on the presence of distinct surface features during an upwelling event in the Gulf of Finland, Baltic Sea (Fig. 1). To isolate and quantify these features, it is important to recap that an upwelling is generally represented by two stages: an active phase and a relax phase (Gurova et al., 2013). The active phase develops when persistent winds stimulate offshore Ekman transport of surface waters. This subsequently generates an upward